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(71) Applicant
International Standard Electric Corporation, (USA-Delaware),
320 Park Avenue, New York 10022, State of New York, United States of America

(72) Inventor
Manfred Kaiser

(74) Agent and/or Address for Service
J. C. Vaufrouard,
ITT Patent Department UK, Maidstone Road, Foots Cray, Sidcup DA14 5HT

(54) Optical coupler

(57) In an optical coupler for connecting optical fibres (4), a waveguide (6) between them consists of a photopolymer which is photopolymerised by light. The shape and the run of the waveguide (6) corresponds to the spatial distribution of the light as emerging from the end faces of the fibres (4).

The photopolymerisation for forming the waveguide (6) between the end faces of the fibres (4) is effected by means of an exposure through the fibres (4).

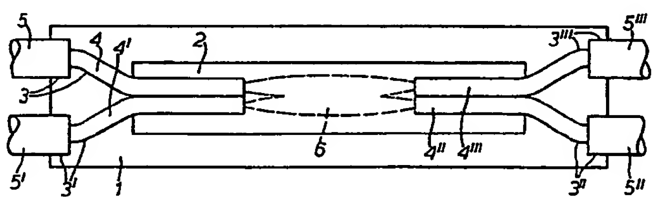

Fig. 1.

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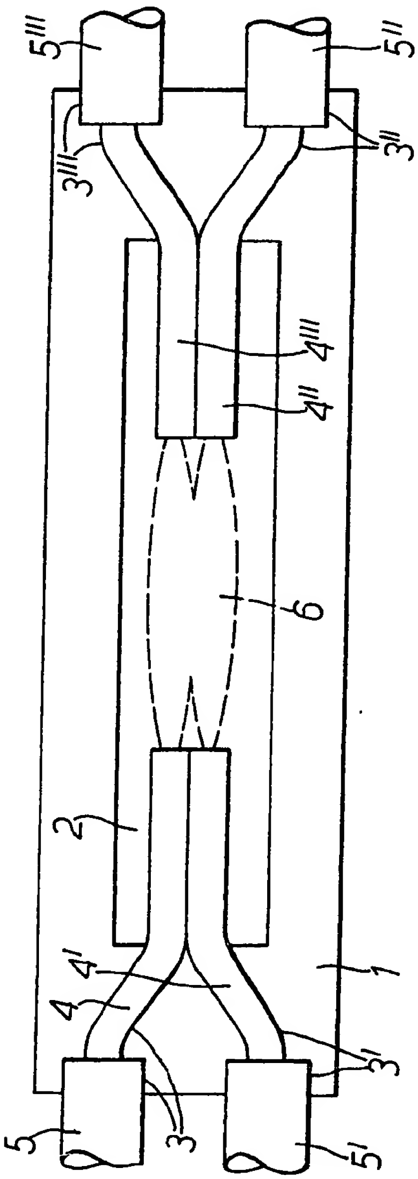


Fig. 2.

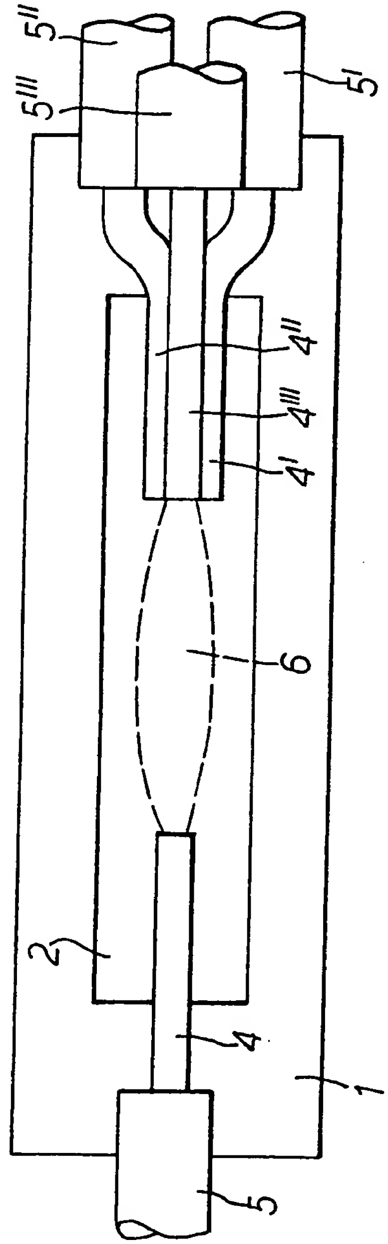
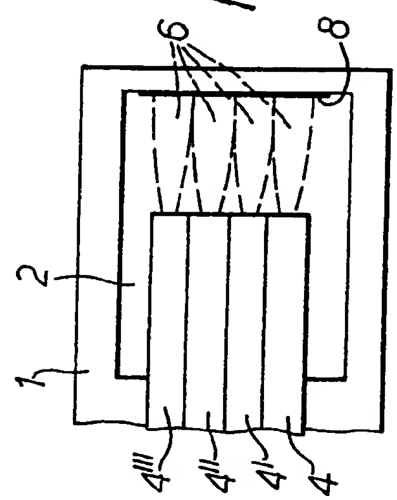


Fig. 4.



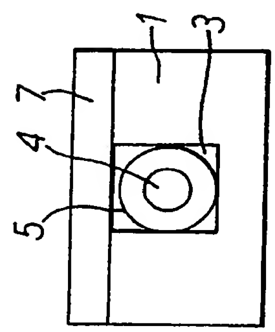


Fig. 3.

SPECIFICATION

Optical coupler

The invention relates to an optical coupler which comprises a photopolymer for connecting optical fibres, and to a method of manufacturing such a coupler.

From German Patent No. 28 27 005 there is known a method of manufacturing an optical coupler capable of being connected to optical fibres. In this method a pourable compound is cast into a housing formed by a substrate with a frame placed thereon, and on this compound, subsequent to evaporation of the solvent, there is placed a photomask bearing the pattern of the optical waveguide of the coupler, with the entire arrangement thereafter being irradiated with ultraviolet light. Following the removal of the photomask, a monomer exists in the compound of the non-exposed waveguide. The waveguide is removed for forming the finished optical waveguide by drying in a vacuum. In this method the exact alignment of the photomask of the optical waveguide with the ends of the optical fibres is important, in order that both parts are in alignment with one another. Also the manufacture and the handling of the photomask involves a considerable cost, because the mask must be kept free from dust and free from scratches.

The invention seeks to provide a low-loss optical coupler which is also more simple to manufacture.

According to one aspect of the invention there is provided an optical coupler comprising a waveguide of a photopolymer for connecting optical fibres, characterised in that both the shape and the run of the waveguide correspond to the spatial output distribution of the light as emerging from the end faces of the optical fibres.

According to another aspect of the invention there is provided a method of manufacturing an optical coupler in which the ends of a plurality of optical fibres are each placed into a groove of a housing comprising a recess, and extend into the recess, that the recess is filled with a photopolymer, and is photopolymerised for forming the waveguide, characterised in that the photopolymerisation is carried out between the end faces of the fibres by way of an exposure through the optical fibres.

The waveguide of the optical coupler is adapted to the fibre geometry of the fibres to be coupled, so that only small losses will result at the joints. For the same reason also no special requirements need be placed on the surfaces of the fibre ends, because by the index adaptation of the photopolymer, the properties of the end faces of the fibre ends are insignificant. It is possible to manufacture both planar and spatial structures of the optical coupler.

The method of manufacturing the optical coupler is simple, because it does not require a photomask, and because the fibre ends do not need to be aligned precisely with respect to one another. Without any additional investment, it is also possible to achieve different coupling factors between the respective fibre ends by employing different times of exposure.

In order that the invention and its various other preferred features may be understood more easily some embodiments thereof will now be described, by way of example only, with reference to the drawings, in which:

Figure 1 is a schematic plan view of a symmetrical optical coupler constructed in accordance with the invention with its top removed,

Figure 2 is a schematic plan view of a spatial structure of an optical coupler constructed in accordance with the invention with its top removed,

Figure 3 is a view from the left of the optical coupler as shown in Figure 2 but with the top thereon, and

Figure 4 is a schematic plan view of part of an optical coupler constructed in accordance with the invention working on the reflection principle with its top removed.

The construction of Figure 1 comprises an oblong housing 1 having a central recess 2 and, on the narrow sides, a number of grooves 3 and 3′ or 3″ and 3‴ for receiving optical fibres 4, 4′, 4″ or 4‴ of corresponding optical waveguides 5, 5′, 5″ and 5‴ respectively. The optical waveguides are only short ends to which incoming or outgoing optical waveguides can be welded; they may be provided with connectors. The end pieces of the fibres 4 and 4′ or 4″ and 4‴ are positioned side by side in the recess 2, with the end faces thereof lying in a common plane. The distance between the end faces of the fibres 4, 4′ and 4″, 4‴ is chosen such that each end face lies within the aperture range of the opposing end face. The recess 2 is filled with a photopolymer which, by an exposure through the fibres 4 to 4‴ forms an optical waveguide 6 between the end faces of the fibres 4 to 4‴. The run and the shape of the optical waveguide 6 corresponds to the spatial output distribution of the light emerging from the end faces of the fibres 4 to 4‴, and is indicated by the dashlines.

The optical waveguide or the fibres thereof are secured in grooves by means of an adhesive which, at the same time, forms a seal for the grooves toward the outside and also effects a strain relief of the optical waveguides. A top part 7 or cover as shown in Figure 3 closes the optical coupler from above.

To the optical waveguides 5 and 5′ it is possible, for example, to connect transmitters with different wavelengths of their transmitted light which is coupled into the optical waveguides 5″ and 5‴. To the optical waveguide 5″ there may then be connected a transmission path of a transmission system, and to the optical waveguide 5‴ there may be connected either a monitor or a measuring instrument.

The further exemplary embodiment of Figure 2 comprises on one side an optical fibre 4 and, on the other side, three optical fibres 4′, 4″, 4‴. The fibres form part of the optical waveguides 5 to 5‴. The optical waveguide 6 lying therebetween is again indicated with respect to its run and its shape, by dashlines. In this spatial structure of the

optical fibres to be coupled to one another, the spacing between the respective end faces of the fibres 4 and 4', 4'' and 4''' is again chosen such that they lie within the aperture range one of another. This optical coupler, can be used, for example, as a star coupler.

Figure 3 is a left hand side view of the optical coupler shown in Figure 2. In this drawing there is additionally shown the top part or cover 7 on the housing 1 of the optical coupler, in order to illustrate the upper termination. Moreover, there can be seen the groove 3 in the housing 1 as well as the optical fibre 4 of the optical waveguide 5.

Figure 4 shows part of an optical coupler which operates on the reflection principle. In this coupler all optical fibres 4 to 4''' are introduced from one side into the housing 1. The wall opposite them is provided with a mirror 8 that reflects light from one fibre into the other fibres. The run and shape of the optical waveguide 6 which is formed in the recess 2 is again denoted by dashlines.

Optical coupler constructions similar to those shown in Figures 2 and 4 can be produced having a different number and a different spatial arrangement of the optical fibres. Such constructions are intended to fall within the scope of this invention.

The manufacture of an optical coupler in accordance with the invention will now be described.

Inside the housing 1, the optical waveguides 5 with the ends of the optical fibres 4 are placed into the grooves 3 and secured with the aid of an adhesive. In so doing the alignment of the fibres 4 as given by the shape of the grooves 3, is sufficient. The correct distance between the end faces of the fibres must be maintained. Thereafter, the recess 2 is filled with a photopolymer. By a predetermined exposure, for example, with ultraviolet light, through all fibres 4, there is produced the waveguide 6 within the overlapping aperture range of the fibres. This is effected in that by the exposure there is caused a refractive index which differs from the surrounding photopolymer. Relative thereto, it is appropriate, within the overlapping aperture range of the fibres and by the exposure, to cause only a partial cross linking of the photopolymer, and to effect the complete cross linking of the entire photopolymer in the recess 2 by way of a subsequent application of heat. Following the placement of the top part 7, the optical coupler is finished. The cross linking of the photopolymer as effected by the exposure with ultraviolet light, is a function of the light current and of the time of action. By the exposure through opposite fibres, there is effected within the overlapping range of the apertures of the fibres, a doubly strong exposure. From this there also follows an almost doubly strong cross linking compared to the surrounding photopolymer. By the complete cross linking, the refractive index of the surrounding photopolymer is then adjusted in such a way that it becomes smaller than within the range cross linked by the exposure. In this way there is achieved the necessary structure of the waveguide 6, in order to safeguard the imaging of the fibre cores of the optical fibres one to another.

Following the partial cross linking of the photopolymers within the overlapping aperture range of the fibres, there may also be effected a diffusing-in or -out of substances which either increase or reduce the refractive index of the photopolymer. In the course of this, the boundary of the previously cross linked range serves as a diffusion retardant. Subsequently thereto, there is then effected the complete cross linking by the application of either ultraviolet light or heat.

When the light exposure times between corresponding fibres are arranged to be of different lengths, the resulting optical waveguide will have different coupling factors between the corresponding fibres.

CLAIMS

1. Optical coupler comprising a waveguide of a photopolymer for connecting optical fibres, characterised in that both the shape and the run of the waveguide (6) correspond to the spatial output distribution of the light as emerging from the end faces of the optical fibres (4).

2. An optical coupler as claimed in claim 1, characterised in that the end faces of the optical fibres (4) to be coupled, lie within the aperture range of the respective opposite optical fibre.

3. An optical coupler as claimed in claim 1, characterised in that all of the optical fibres enter from the same side and their ends face a light reflector.

4. An optical coupler as claimed in claim 3 wherein the end faces of the optical fibres lie in a common plane.

5. An optical coupler as claimed in any one of claims 1 to 4, characterised in that the waveguide (6) comprises different coupling factors between the various fibres (4) to be coupled.

6. An optical coupler substantially as described herein with reference to the drawings.

7. A method of manufacturing an optical coupler in which the ends of a plurality of optical fibres (4) are each placed into a groove (3) of a housing (1) comprising a recess (2), and extend into the recess (2), that the recess (2) is filled with a photopolymer, and is photopolymerised for forming the waveguide (6), characterised in that the photopolymerisation is carried out between the end faces of the fibres by way of an exposure through the optical fibres.

8. A method of manufacturing an optical coupler as claimed in claim 7 , characterised in that subsequently to the photopolymerisation of the overlapping aperture ranges of the fibres, the refractive index of the non-cross-linked photopolymer is reduced by diffusing-in or -out a suitable substance.

9. A method of manufacturing an optical coupler as claimed in claim 7 or 8, characterised in that the exposure is carried out with ultraviolet light.

10. A method of manufacturing an optical coupler as claimed in any one of claims 7 to 9, characterised in that by the exposure there is effected a

partial photopolymerisation, and that a complete curing of the photopolymer is effected by the application of heat.

11. A method of manufacturing an optical coupler as claimed in any one of claims 7 to 10, characterised in that the time of exposure through the individual optical fibres is differently long.

12. A method of manufacturing an optical coupler substantially as described herein.

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